affixed, but oxidised in place of being left bright. Recently a new mark has been introduced in Ireland, consisting of a small numbered tag attached to the base of the dorsal fin by means of a ring; marks of this pattern are made of various size to suit any fish from a smolt upwards.

## ENTOMOLOGY FOR THE YOUNG.

THIS book is not a scientific treatise; it is intended, as the author tells us in the preface, "to encourage the intelligent life-study of insects by our younger folk, to discourage collecting, and to stimulate the profitable employment of one's eyes and ears in town or country." This object is a very estimable one, and the author has done much to produce a book admirably adapted for this purpose.

It is divided into seven chapters, each containing many stories of insect life. The general introduction

Green-veined White Butterfly resting. From "The Story of Insect Life."

deals with all manner of subjects in a clear and very simple way, such as structure, eggs, metamorphosis, fertilisation of plants, the story of the wild arum, resemblance of plants to insects, &c. Then follows a chapter on beetles, some of our common forms being simply described. Earwigs, cockroaches, crickets, and grasshoppers form the theme of chapter iii., and dragon-flies, May-flies, &c., that of chapter iv. Now and again the author, unfortunately, pounces on scientific names. For many reasons, in a book for young people, these are best left out, particularly if wrong ones are used, as on p. 104, where the steel-blue wood wasp (*Sirex juvencus*) is called *Sirex noctilo*!

Some of the stories form delightful reading, such as the story of the hive bee, p. 207.

Seventy-six pages are devoted to butterflies and moths, and then the final chapter gives a few brief notes on bugs, frog-hoppers, gnats, and other flies that may attract the young person's attention.

The illustrations from photographs are mostly excellent, and some beautiful pictures are reproduced of localities where water insects abound. The author, unfortunately, in one has made a grievous error, for in Fig. 119 he gives the head of a male mosquito, *Theobaldia annulata*, as that of a female gnat, and refers to this in the text. For the young we should be just as careful to be accurate as for people more matured.

The eggs of the vapourer moth are not in a natural position in Fig. 17, and, again, a badly set and damaged tortoiseshell butterfly is clumsily stuck on an iris blossom (Fig. 86) in a very unnatural way. There are also many entomological errors.

The plates will be sure to attract the young mind, and they are excellently reproduced, but the artist appears to have a quaint idea of some of the insects, such as the blow-fly on plate viii., and also the water boatman. In spite of such faults, the book is one that may be recommended to all young folk, as it not only supplies a want, but fills that want in a clear and pleasant style. FRED. V. THEOBALD.

[1] "The Story of Insect Life." By W. P. Westell. Pp. 339; illustrated. (London: Robert Culley, n.d.) Price 5s. net.

## LORD KELVIN.

IN NATURE for September 7, 1876, there was published, with the engraved portrait by Jeans, in the series of "Scientific Worthies," an account of Lord Kelvin, then Sir William Thomson, and of the scientific work, extending then over more than thirty years, by which he had rendered himself illustrious in physical science. Thirty-one years have elapsed since that appreciation was written, and now we have to mourn that this life of wonderful activity has come to its natural close. At the ripe age of eighty-three, as full of honours as of years, Lord Kelvin has passed away. To say that his eye was not dimmed, nor his natural force abated, would be scarcely strictly true, yet he retained to the last the exercise of his intellectual powers. The vigour and keenness with which he entered into the discussions at the British Association meeting at Leicester in August last were truly remarkable at his advanced age. It was in the course of making experiments in a corridor in his country house, Netherhall, Largs, that he contracted the chill which brought about the fatal end.

The article of 1876 gave in some detail those scientific achievements which had then made him famous; and a glance at its contents will show in brief what these were. While still an undergraduate at Cambridge, he had made valuable mathematical investigations in relation to Fourier's theorems, and in their applications to the motion of heat and to hydrodynamics. In these investigations will be discovered the foundation of the method of evaluating geological dates from underground temperatures upon which subsequently he built his famous conclusions as to the age of the earth. In the years which followed, during his early occupancy of the chair of natural philosophy at Glasgow, Lord Kelvin was largely occupied, in constant association with Joule, with the development of thermodynamics, to which not his least contribution was the theory of the dissipation of energy. This was followed by investigations into electrostatics and the theory of magnetism, contact electricity, thermo-electricity, the mechanical energies of the solar system, the calculation of the tides, the size of atoms, and vortex motion. That which, however, directed popular attention to his scientific attainments was not so much these deep investigations as his connection with the more practical problems of ocean telegraphy. The pos-

sibility of an Atlantic cable was in the early 'fifties a much-discussed question: and the mathematical investigation which Lord Kelvin made of the conditions governing the propagation of signals in long submarine cables proved to be the most important contribution to the practical solution of that problem. He showed that the retardation must be proportional to the square of the length of the cable; and, further, he applied the theorems of Fourier to predict the degree of attenuation of the impulses on their arrival at the distant end. This was followed by the invention of the mirror galvanometer, and later by the siphon recorder, with both of which instruments his name will ever be associated. The final success of the Atlantic cables of 1865 and 1866 was a triumph for his inventive ingenuity no less than for his mathematical skill and insight. He had likewise been brought intimately into nautical matters, leading him to devise the method of taking flying soundings, and to publish a set of tables for facilitating the use of Sumner's method at sea. To heighten his public fame he also re-modelled the mariner's compass by radical improvements which quickly established its superiority to all earlier forms.

All this was duly recounted in the article of 1876, and might well suffice to place him in the very first rank of physicists had he achieved nothing more. Von Helmholtz, summing up his intellectual attainments at that date, had remarked upon his method of treating the problems of mathematical physics how he had "striven with great consistency to purify mathematical theory from hypothetical assumptions which were not a pure experience of facts." He maintained that "the gift to translate real facts into mathematical equations, and *vice versâ*, is by far more rare than that to find the solution of a given mathematical problem"; adding, "And in this direction Sir William Thomson is most eminent and original." Happily for science this gift continued to be exercised for thirty years after von Helmholtz penned this appreciation of his friend. As the years went on Lord Kelvin continued with marvellous activity of mind and body to add to his long list of scientific labours.

It has been noted above at how early a date, namely, in 1842, Lord Kelvin had published the germ of his theories about the age of the earth. This was in a paper on the linear motion of heat which appeared in the *Cambridge and Dublin Mathematical Journal*. This same subject he had made the topic of his inaugural lecture in 1846 on taking up his professorship at Glasgow. He returned to it in 1876 as the theme of his address as president of the Physical and Mathematical Section of the British Association at Glasgow. To the geologists who demanded unlimited time for the operation of these formative actions, which, on the abandonment of catastrophic notions, they had assumed to proceed with constant uniformity, Lord Kelvin announced with the utmost confidence that they must hurry up their phenomena, since the age of the earth as a habitable planet, so far from being unlimited, could not possibly exceed four hundred millions of years, and was more probably within twenty millions of years. The proposition was supported by several converging lines of argument. The surface temperature could not be what it was, considering the average conductivity of rocks and the gradient of temperatures found underground, if the cooling process had proceeded from an unlimitedly long anterior date. The heat of the sun itself must be constantly dissipated, and its temperature sinks; and with the cooling of the sun the earth also cools. Its form, in relation to centrifugal forces, was incompatible with the hypothesis of an unlimited time since it was a fluid mass. The controversy which arose, as the biologists and geologists endeavoured to combat these arguments, lasted for a quarter of a century; and the end is indeed not yet.

Hydrodynamics is a branch of natural philosophy in which the Cambridge school under Stokes has always been strong; and Lord Kelvin, as a pupil and friend of Stokes, worked much at it. Hydrodynamics was indeed continually in Lord Kelvin's thoughts. His brilliant speculation of the vortex-atom remains—if we are to except recent electric theories of matter—the one and only hypothesis of the ultimate structure of matter that has yet been found to hold its own against destructive criticism. It has not yet been shown to be impossible or self-contradictory. Apart from this, his other investigations into hydrodynamics have been most fruitful. He discussed the conditions of stability of fluid motion in a large number of cases, some of them of practical importance. Within the past two years he contributed to the Royal Society of Edinburgh a series of papers on deep sea waves, papers which are full of characteristic applications of Fourier's theorems, and show unabated keenness in following out an intricate analysis. In elasticity and the kindred problems of dynamics, the influence of the master's hand is no less evident. The article which he contributed to the "Encyclopædia Britannica" on elasticity will remain a classic of science for many years. Those who are intimate with Lord Kelvin's work generally will know how much in this article there is that lies behind his other studies. His continual reference to the analogies which he found between the phenomena of magnetism and of electricity and those of elastic solids shows the working of his mind, and the fundamental views which he held on elasticity dominate alike his Baltimore leetures of 1884 and the papers on molecular physics of his latest years.

To the science of electricity, Lord Kelvin's contributions have been no less notable. Imbued with admiration for Faraday's experimental work, Lord Kelvin early set himself to ascertain whether the phenomena of electromagnetism can be explained on an elastic solid theory. Although it was left to Maxwell to carry to fruition this part of the subject, it was Kelvin's merit to have first applied mathematical analysis to the facts revealed by Faraday's researches. It was in 1847 that he first proposed a mechanical representation of magnetic force; and to this subject he returned in 1890, in an article first published in the third volume of his collected mathematical and physical papers. It was in the early days, too, that he investigated the conditions of the discharge of a Leyden jar in circuits possessing self-induction, predicting mathematically the fact that under certain conditions these discharges would be found to consist of electric oscillations. This discovery was published in 1853. Later, Fedderson and others observed these oscillations experimentally; and in the 'eighties this abstract research of Lord Kelvin's became the starting point of the investigations of Sir Oliver Lodge and of the lamented Heinrich Hertz, leading directly to wireless telegraphy.

In 1851 Lord Kelvin, impelled by the characteristic precision of his scientific character, and urged by the needs of exact measurement in telegraphy, had already adopted the absolute system of measurement initiated by Gauss, and extended by Weber. In Lord Kelvin's hands the absolute system of measurement, and with it the adoption of the metric system of standards, became almost an article of creed. In season and out of season he urged the superiority of the decimal measures over the ordinary British ones; and, consistently, he strove to bring all scientific measurements into terms of the fundamental metric

units of length, mass and time. Moreover, toward the end of the 'fifties, electric measurement, in the hands of the cable engineers, had become much developed, and instruments of a precision exceeding anything known then in the physical laboratory had been devised for practical use. In 1861 Lord Kelvin secured the appointment by the British Association of a committee on electrical standards, a committee of which also Wheatstone, Matthiessen, Fleeming Jenkin, and, later, Siemens, Clerk Maxwell, Joule, and Carey Foster were members. Year after year this committee, with younger men added, has produced its reports with little intermission, and the system of units which it evolved is practically that which is internationally recognised and of legal force. Twice Lord Kelvin gave public expositions of the system in set addresses, at a South Kensington conference in 1876, and before the Civil Engineers in 1883. The latter of these discourses is in Lord Kelvin's most characteristic style, and even now, after twenty years, some of it is hard reading for any but a professed physicist. But mere hardness never daunted Lord Kelvin. In the same lecture, speaking of a particular point in the system of absolute measurement, he said :— "It may be hard to accept, but the harder it is the more it is worth thinking of." The acceptance and rapid development of the international system, based on the centimetre, the gram, and the second, is due to Lord Kelvin more than to any other man.

After the adoption of the new units by the International Congress at Paris in 1881, Lord Kelvin devoted much attention to the production of commercial instruments for the measurement of current, potential, and electric power. Relying confidently on the rightness of abstract principles, he produced a series of ampere-balances for currents of different strengths, thus putting into the hands of practical engineers a set of instruments of remarkably great accuracy and of remarkable range. When occupied with the tides, in the 'seventies, he had devised a machine for analysing the harmonic components of the periodic tidal variations, the essential part of this harmonic analyser being a mechanical integrating device of globe, disc, and cylinder, first suggested by his brother, Prof. James Thomson. It seemed a bold thing to apply such mechanism to evaluate the integrals indicated by Fourier's analysis; but Kelvin's machine justified the hardihood of the conception. When in the 'eighties he had before him the problem of constructing an electricity meter which should continuously integrate the varying product of current and voltage of an electric supply, he again had recourse to the same integrating mechanism. And, here, it may be remarked in passing that it is to Lord Kelvin's evidence before the Parliamentary Committee in 1879 that we owe the circumstance that the Board of Trade adopted as its official unit of electric energy the value of one thousand volt-ampere-hours. It was once upon a time proposed to denominate this unit—now universally employed—by the name of one "kelvin." Lord Kelvin's innate modesty caused him to reject the suggestion. Surely the time has now come for the final incorporation of his name into the international system, thus linking it with those of Volta, Ampère, Ohm, Coulomb, Watt, Faraday, Joule, Henry, and Gauss.

Lord Kelvin had a peculiar predilection for illustrating recondite notions by models. He once said that he could never understand a thing until he could make (or conceive) a model of it. His chain of gyrostats to illustrate the rigidity of the ether, his systems of crystal models made of little wooden rods and balls held in stable equilibrium by india-rubber bands, are but two examples of a mode of using the concrete to realise the abstract that he practised continually. He was fond of introducing into abstract dynamics terms derived from other sciences, geodesy, and crystallography. Amongst the bye-products of his genius may be found enshrined in the Proceedings of the Royal Society a short paper containing the essentials of the theory of the designing of wall-paper patterns; its title, however, is "The Homologous Partition of Space."

Of Lord Kelvin's later work on molecular physics, the "tactics of a crystal," the problems of æolotropic elasticity in relation to optical as well as magnetic and electric phenomena, it is less easy to speak. The lectures which he gave at Baltimore in 1884 to "his twenty-one coefficients," the members of the group of accomplished physicists who then sat at his feet day after day, while he led them through the mazes of the elastic-solid theory and the newly-invented spring-shell molecule, remain a witness to his extraordinary fertility of intellectual resource. All his life he had been endeavouring to discover a rational mechanical explanation for the most recondite phenomena—the mysteries of magnetism, the marvels of electricity, the difficulties of crystallography, the contradictory properties of ether, the anomalies of optics. And during the preceding decade he had been confronted with a great generalisation which did not fit in with this method of intellectual apprehension, which had become to him instinctive. While Kelvin had been seeking to explain electricity and magnetism and light mechanically, or as mechanical properties, if not of matter, at least of ether, Maxwell had boldly propounded the electromagnetic theory of light, and had drawn all the younger men after him in acceptance of the generalisation that the waves. Lord Kelvin had never accepted Maxwell's theory. It is true that in 1888 he gave a nominal adhesion; but later withdrew it, preferring still to think of things in his own way. Kelvin's Baltimore lectures of 1884, abounding as they do in a host of brilliant and ingenious points, and ranging from the most recondite problems of optics to speculations on crystal rigidity and molecular dynamics, leave one with a sense of being a sort of protest of a man persuaded against his own instincts, and struggling to find new expression of his thoughts so as to retain his old ways of regarding the ultimate dynamics of physical nature. During the last few years of his life Lord Kelvin himself revised these lectures, enriching them with a variety of new materials, and coordinating the old. He was intensely interested in the new problems raised by the discovery of radium; and in its astonishing property of continuously emitting heat. He combated strenuously the hypothesis of Rutherford that this was to be explained by a spontaneous decomposition of the atom; and to the very last he was seeking for other explanations.

At the present time, when so much of the new knowledge is in a state of flux, it would be entirely premature to attempt to evaluate the ultimate importance of Lord Kelvin's later writings on radium and on the "electrions." Suffice it to say that he brought to bear on these things the same illuminating genius, the same keen analytical instincts, that he had shown throughout his long career.

To two generations, if not three, of scientific men his work, his presence, his mathematical genius, his enthusiastic faith in first principles, and his unfailing gentle courtesy have been an inspiration and a perpetual stimulus. So he rests from his labours, and his works do follow him. SILVANUS P. THOMPSON.

### LORD KELVIN'S FUNERAL IN WESTMINSTER ABBEY.

The decision taken by the Dean of Westminster to accord to Lord Kelvin burial in Westminster Abbey met at once with a warm and responsive echo of satisfaction on the part of men of science and the com-

munity generally. In the Abbey he has joined a noble company of departed worthies—Newton, Herschel, Lyell, Spottiswoode, Darwin—names that perpetuate some of the most glorious and imperishable achievements in natural knowledge. Especially gratifying must it be to the Royal Society to feel that the remains of their illustrious past-president find a resting-place side by side with those of Sir Isaac Newton.

The representative gathering that filled the Abbey on Monday, December 23, afforded ample testimony to the wide and varied interests, apart from pure science, that dominated the career of Lord Kelvin. Not only a brilliant moving figure in the hierarchy of science, he was also a great citizen, ever mindful of the best traditions of English public life.

The funeral service, which commenced at noon, was of the most impressive character. The King was represented by His Grace the Duke of Argyll, K.G.; the Prince of Wales by Lt.-Col. Sir Arthur Bigge, G.C.V.O.; and the Duke of Connaught by Major L. Green-Wilkinson. The Princess Louise (Duchess of Argyll) was present, attended by a lady and gentleman in waiting. Seats in the choir stalls were occupied by:—

Lady Rayleigh, the Russian and Italian Ambassadors, Mr. J. Ridgely Carter, representing the American Ambassador; Baron von Stumm, representing the German Ambassador; and Mr. Ijiuin, representing the Japanese Ambassador; the Lord Mayor of London (who was robed), and the Master of the Clothworkers' Company. The First Lord of the Admiralty, Lord Tweedmouth, accompanied by his secretaries, attended to represent the Board of Admiralty. The Lord President of the Council was represented by Mr. Almeric FitzRoy.

At the Chapter House a procession was formed, which, headed by the choir and officiating clergy, slowly wended its way from the Chapel of St. Faith through the cloisters, and, while the hymn "Brief life is here our portion" was being sung, to the nave, and thence to the lantern, beneath which the coffin was temporarily deposited. The order was as follows:—

Clergy and choir; bier; pall bearers; chief mourners; Institute of France, M. G. Lippmann, For.Mem.R.S., M. Henri Becquerel, in addition to M. Darboux, For.Mem.R.S., perpetual secretary, who took part as a pall bearer; Lord Mayor of London; Master of Clothworkers' Company; the Royal Society; the Royal Society of Edinburgh and other British and foreign learned societies; Universities of Cambridge and Oxford; University of Glasgow and other Glasgow delegations; University of Edinburgh and Corporation of Edinburgh; other British universities.

A guard of honour of the Electrical Engineer Volunteers, of which Lord Kelvin was Colonel-in-Chief, lined the cloisters, Colonel R. E. B. Crompton, C.B., commanding. The guard fell in at the end of the procession, and took up a position in the nave.

The pall bearers and chief mourners were as subjoined:—

*Pall Bearers.*

Lord Rayleigh, O.M. (President of the Royal Society).
Mr. J. Morley, O.M. (Secretary of State for India).
Sir Archibald Geikie, K.C.B., Sec.R.S. (President of the Geological Society).
Prof. A. Crum Brown, F.R.S. (Royal Society of Edinburgh).
The Master of Peterhouse, Cambridge (Dr. A. W. Ward).
Sir J. Wolfe-Barry, K.C.B., F.R.S. (Institution of Civil Engineers).
Sir Edward H. Seymour, O.M. (Admiral of the Fleet).
M. Gaston Darboux, For.Mem.R.S. (Perpetual Secretary of the Paris Academy of Sciences).
The Lord Strathcona and Mount Royal (High Commissioner for Canada).
Sir George Darwin, K.C.B., F.R.S. (University of Cambridge).
Dr. MacAlister (Principal of the University of Glasgow).
Dr. R. T. Glazebrook, F.R.S. (Institution of Electrical Engineers).

*Chief Mourners.*

Dr. J. T. Bottomley, F.R.S.
Mr. G. King.
Mr. James Thomson.
Mr. W. Bottomley.
Sir Alex. Brown.

Mr. W. Crum and two others, with four grand-nephews, Mr. D. King, Mr. J. F., Mr. W., and Mr. G. Bottomley.

On the part of the Royal Society, in addition to pall bearers and other Fellows who also represented universities, there were present Mr. A. B. Kempe (treasurer), Prof. Larmor (secretary), Sir W. Crookes (vice-president), Sir J. Stirling, Sir John Evans, Major MacMahon, &c., and Mr. R. Harrison (assistant secretary).

It is unfortunately impossible to find space here to print the long list of representatives of British universities, scientific societies, and institutions present at the funeral, and we are only able now to state that the following foreign societies were represented in addition to the Paris Academy of Sciences already mentioned:—

Imperial Academy of Sciences of Vienna, Lord Rayleigh; Accademia dei Lincei, Rome, Sir Norman Lockyer, Prof. J. J. Thomson, Sir David Gill, and others; the Elektrotechnischer Verein of Berlin, Mr. A. Siemens; Societá Italiana di Fisica, Associazione Elettrotecnica Italiana, and Phys. Verein Frankfurt a.M., Prof. Silvanus P. Thompson, &c.

## NOTES.

WE announce with deep regret the death of Dr. Janssen, director of the Meudon Astro-Physics Observatory, at eighty-three years of age.

A REUTER message from Copenhagen states that experiments made by the Amalgamated Radio-Telegraph Company of London and Copenhagen, owners of the Poulsen system of wireless telegraphy and telephony, show that wireless Poulsen telegrams between Newcastle and Copenhagen and Berlin and Copenhagen can be written directly from the receiver with ink as in the case of telegraphy by wire.

THE Royal Statistical Society's Guy medal in gold has been presented to Prof. F. Y. Edgeworth for his services to statistical science.

DR. THOMAS ANNANDALE, Regius professor of clinical surgery in the University of Edinburgh, died on December 20 at sixty-nine years of age.

ON Saturday next, December 28, Sir David Gill, K.C.B., F.R.S., will deliver the first of the annual course of juvenile lectures at the Royal Institution on "Astronomy, Old and New." The remaining lectures will be delivered on December 31, January 2, 4, 7, and 9.

MR. ELIHU THOMSON, writing from the General Electric Company, Lynn, Mass., U.S.A., comments upon the description of the exhibition of globe lightning in West Australia described in our issue for October 31 (vol. lxxvi., p. 671), and provides particulars of another case brought before his notice by a friend. The phenomenon referred to by Mr. Thomson is said to have appeared as a ball of yellow flame continuously in motion with a central nucleus rose-red in colour, and to have exhibited many points of similarity with the globular lightning seen in Australia on the occasion mentioned in our previous note. From Mr. Thomson's letter it is not clear whether the report made to him relates to globular lightning or to a fireball.

IN the report of the Bristol Museum and Art Gallery for 1907 the committee announces that the success of the combined institution during the period under review has been very pronounced, the total number of visitors considerably exceeding half a million. A new departure is the